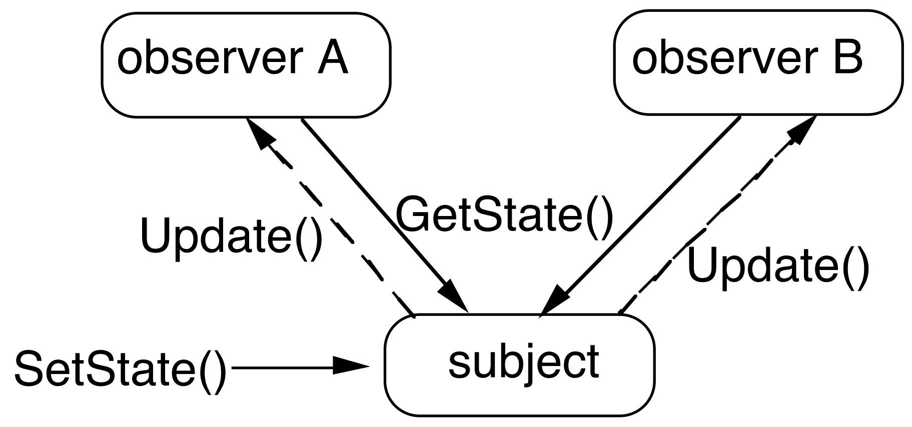
CS 696 Functional Programming and Design
Fall Semester, 2015
Doc 17 FRP
Nov 5, 2015

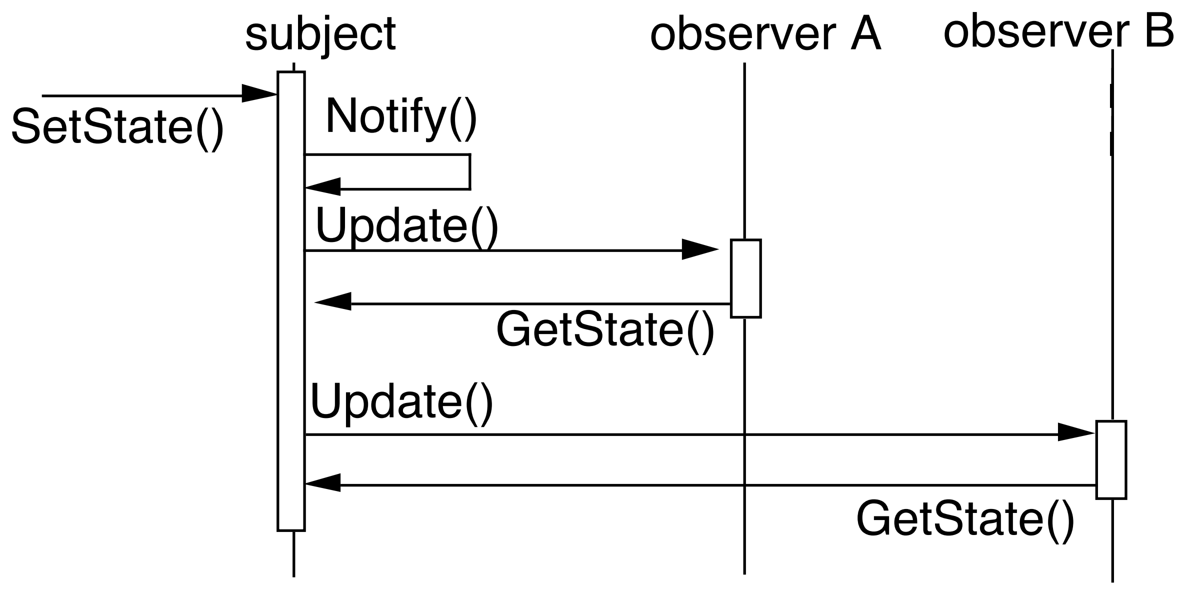
Flow of Control

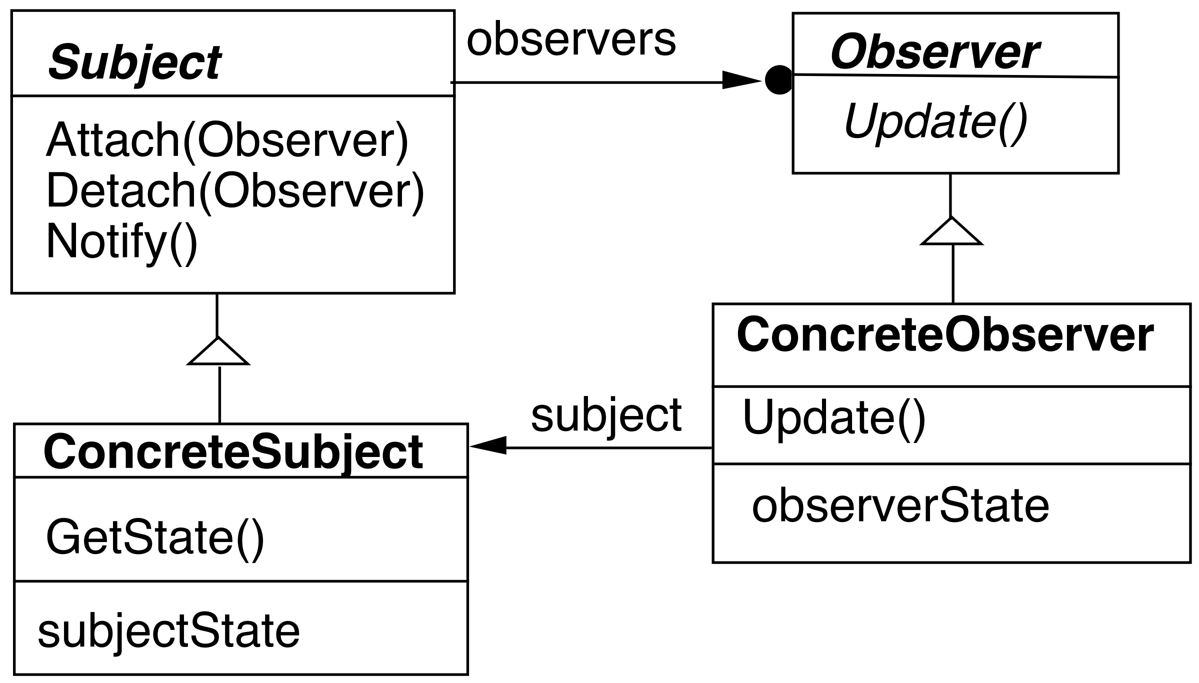
```
x = 2
y = x * 2
z = buzz(y)
if z < 10
    w = foo(z)
else
    w = bar(z)
```

```
(-<> 2
    (* 2)
    buzz
    (if (< <> 10)
        (foo <>)
        (bar <>)))
```

Observer Pattern







Java Example

```
class Counter extends Observable  {
    private int count = 0;

    public int value()              {  return count; }

    public void increase() {
        count++;
        setChanged();
        notifyObservers( “INCREASE” );
    }

    public void decrease()  {
        count--;
        setChanged();
        notifyObservers( “DECREASE” );
        }
    }
```

Java Observer

```
class IncreaseDetector implements Observer {
	public void update( java.util.Observable whatChanged, java.lang.Object message) {
		if ( message.equals( “INCREASE” ) )  {
			Counter increased = (Counter) whatChanged;
			System.out.println( " changed to " +  increased.value());
		}
	}

	public static void main(String[] args) {
		Counter test = new Counter();
		IncreaseDetector adding = new IncreaseDetector();
		test.addObserver(adding);
		test.increase();
}
```

Flow of Control

```
    public static void main(String[] args) {
        Counter test = new Counter();
        IncreaseDetector adding = new IncreaseDetector();
        test.addObserver(adding);
        test.increase();
}
```

```
    public void increase() {
        count++;
        setChanged();
        notifyObservers( “INCREASE” );
    }
```

Flow of control not explicit

Don’t see that increase() executes code in IncreaseDectector

Flow of Control - Explicit

```
class Counter extends Observable  {
        private int count = 0;
        private IncreaseDetector observer =     new IncreaseDetector();

        public int value()                { return count; }

        public void increase() {
                count++;
                observer. update(this, null);
        }
}
```

But less flexible

- Only one observer
- Have to modify code to add more or change observer

Observer Pattern

Reduces coupling between subject & observers

- Subject can have any number of observers
- Subject does not know type of the observers

Flow of control is obscured

Observer Pattern - Basic Steps

Subject changes

- You write code to trigger notify to observers

Observer

- Get notified that subject changed
- You write code to react to the change

Java Listeners

You add a listener to an event source

The event source triggers the notification

You write code in listener to react to the event

```
public class Beeper extends JPanel  implements ActionListener {
    JButton button;

    public Beeper() {
        super(new BorderLayout());
        button = new JButton("Click Me");
        add(button, BorderLayout.CENTER);
        button.addActionListener(this);
    }

    public void actionPerformed(ActionEvent e) {
        Toolkit.getDefaultToolkit().beep();
    }
```

Clojure Observer

```
(def counter (atom 0))

(defn counter-observer
  [key pointer old new]
  (when-not (== old new)
    (if (< old new)
      (println "Increase")
      (println "Decrease"))))

(add-watch counter :example counter-observer)

(swap! counter inc)
```

Like listener
We just write code to
- React to event
- Register for updates

Changing the atom automatically calls the observer function

Listener - Basic Steps

Subject changes

- ~~You write code to trigger notify to observers~~

Observer

- Get notified that subject changed

- You write code to react to the change

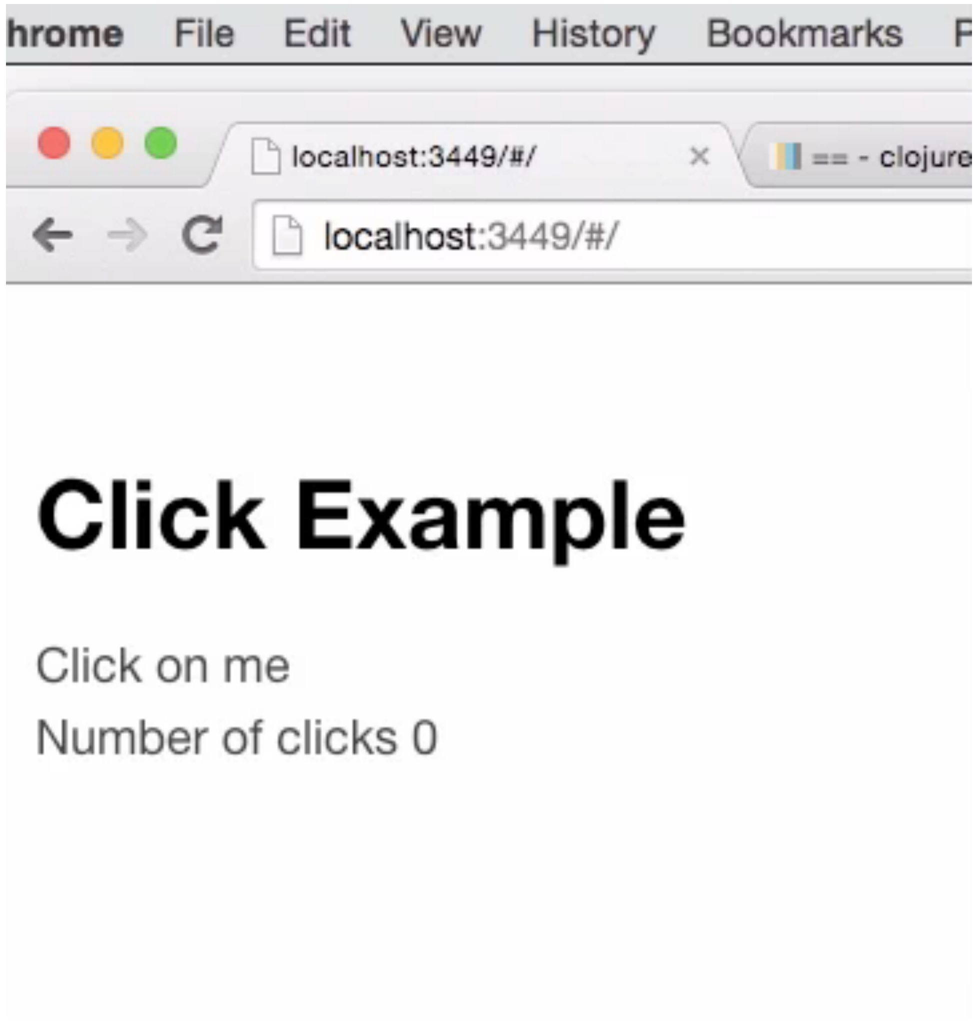
React-Clojure Example

```
(def click-count (atom 0))

(defn stateful-with-atom []
  [:div "Number of clicks " @click-count])


(defn clicker []
  [:div {:on-click #(swap! click-count inc)}
   "Click on me"])


(defn home-page []
  [:div [:h2 "Click Example"]
   [clicker]
   [stateful-with-atom] ])
```



Click Example

Click on me
Number of clicks 0

React-Clojure - Basic Steps

Subject changes

~~You write code to trigger notify to observers~~

Observer

Get notified that subject changed

~~You write code to react to the change~~

Basic Idea of Reactive Programming

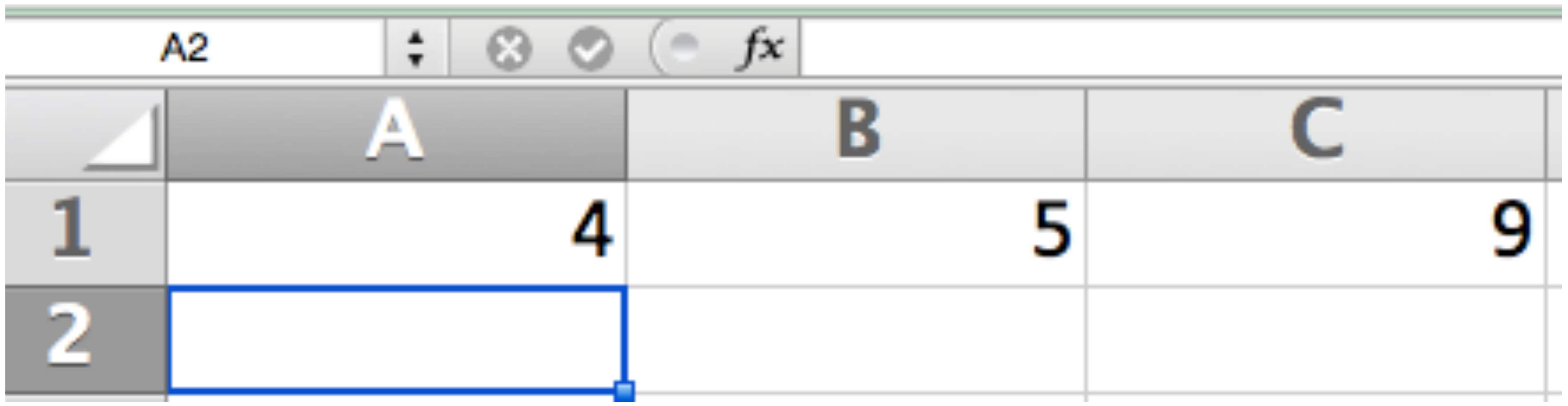
When you change the value of a variable

    All uses of that variable are automatically updated

Reduces observer pattern to just using a variable

Common Example - Spreadsheets

=$A$1 + $B$1



	A	B	C
1	4	5	9
2			

Reactive Programming

Programming paradigm oriented around data flows and the propagation of change

This means that it should be possible to express static or dynamic data flows with ease in the programming languages used, and that the underlying execution model will automatically propagate changes through the data flow

Wikipedia

General programming but often used in

GUI

Networking

Java

```
b = 1
c = 2
a = b + c
b = 3
```

what is a?

Spreadsheet

```
let $A$1 = 1
let $B$1 = 2
let $C$1 =$A$1 + $B$1
```

Now set $A$1 = 3

what is $C$1

Reactive Programming - Types

Imperative

Object-oriented

Functional

Examples

Elm - web

Rx

- Microsoft
- RxJS
- RxJava (Netflix port of RxJS)

ReactiveCocoa

- Objective-C, Swift

React

- Facebook

Functional Reactive Programming (FRP)

1997 - Elliott & Hudak
    Fran - reactive animatons

FRP is about handling time-varying values like they were regular values.

FRP is a declarative way of modeling systems that respond to input over time.

Higher Order FRP

Elliott & Hudak’s work

Time is a first-class citizen

Modeled time as continuous

Synchronous

Has some practical limitations

First-Order FRP

Elm - http://elm-lang.org

the best of functional programming in your browser

```
jump : Keys -> Model -> Model
jump keys mario =
  if keys.y > 0 && mario.vy == 0
    then { mario | vy <- 6.0 }
    else mario
```

Event driven

Synchronous or Asynchronous

Asynchronous Data Flow

- Reactive Extension (Rx)
  - RxJS
  - RxJava (Netflix)
- ReactiveCocoa
- Bacon.js

Event Driven

Asynchronous only

- Netflix use RxJava, RxJS
  - Network traffic
    - Reactive API backend services
  - GUI

RxJava & Clojure

Clojure Reactive Programming
    Borges, March 2015

Covers Rx programming in Clojure

On-line from SDSU library

Chapter 1 - history of FRP
    Source for previous slides

React - Facebook

React - Javascript

  First release 2013

React Native - iOS & Android

One-way data flow

Virtual DOM

Server-side rendering (JavaScript isomorphism)

  Facebook, Netflix, PayPal

React & Clojure

Om
- First release on Github Jan 2014
- Om.next - coming soon

Reagent
- Simpler than Om
- First release Dec 2013

Quiescent
- First release Feb 2014

Reagent Resources

https://github.com/reagent-project/reagent

  Github repository

http://reagent-project.github.io/

  Short tutorial

https://github.com/reagent-project/reagent-cookbook

  Examples

To Start a Reagent Project

```
lein new reagent projectname
```

Live Development Updates

Figwheel

```
lein figwheel
```

Devcard

```
lein figwheel devcards
```